INSTRUCTION MANUAL

FOR THE

CRYSTAL MONITORED SIGNAL GENERATOR

TYPE 211-A

1022

BOONTON RADIO COMPANY

Green Pond Road Rockaway, New Jersey

U.S.A.

Printed in U.S.A.

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CRYSTAL MONITORED SIGNAL GENERATOR TYPE 211-A

I. SPECIFICATIONS.

A. GENERATOR TYPE 211-A.

1. RF Output
   0.1 microvolt to 0.2 volt across a 50-ohm load. Monitored by a set-to-line type meter. Internal impedance of Signal Generator is 50 ohms at panel jack.
2. Master Oscillator
   - *a.* Output frequency range - 88 to 140 mc.
   - *b.* Initial frequency accuracy - better than ±0.1%.
   - *c.* Standardized accuracy - substantially equivalent to that of the crystal oscillator.
   - *d.* Frequency-temperature stability - better than 0.005%/°C.
   - *e.* Spurious frequency modulation - less than 2.5 kc deviation at 100% AM.
3. Crystal Oscillator
   - *a.* Output frequencies - 110.100 mc or 114.900 mc.
   - *b.* Frequency-temperature stability - better than ±0.0035% from 10° C. to 50° C.
4. Spurious RF Output Voltages from Master or Crystal Oscillator - better than 40 db below the carrier output level.
5. Amplitude Modulation
   - *a.* Modulation capability - 0 to 100%, using either internal 400 or 1000 cycle source, or external audio source.
   - *b.* Input requirements from external source - Approx. 2 V RMS into 100,000 ohms.
   - *c.* Modulation meter (actuated by demodulated carrier) - two ranges, 0-30% and 30-100%.
   - *d.* Internal AF oscillator - 400 or 1000 cycles at 1.0% or less distortion.
6. Overall Audio Characteristics (from modulation input to demodulated output)
   - *a.* Frequency fidelity - ±0.5 db from 30 to 11,000 cycles
     - ±0.1 db from 90 to 150 cycles
     - ±0.1 db from 9500 to 10,500 cycles
   - *b.* Total harmonic distortion - 5% or less at 95% modulation
   - *c.* Phase shift - less than 0.25° at 30 cycles
     - approx. 10° at 11,000 cycles
   - *d.* Audio test voltage - at 50% modulation: approx. 4.6 V RMS on "+20V DC" post
     - approx. 3.0 V RMS on "4 μf" post
7. Mechanical
   - *a.* Panel dimensions: Standard 19" relay rack panel, 10½" high.
   - *b.* Overall dimensions including dust covers: Width 19½", height 10½" depth 9½".
   - c. Weight including dust covers: 28 lbs.

B. POWER SUPPLY TYPE 211-AP1.

1. Power Input - 105 to 125 V, 50-60 cycles, 150 watts
2. Power Output
   - *a.* Regulated DC to 211A Generator - 200 V at 40 ma.
   - *b.* Regulated DC to 211A Generator - 575 V at 50 ma.
   - *c.* Unregulated AC to 211A Generator - 7.4 V at 2.65 amp.
3. Mechanical
   - *a.* Panel dimensions: Standard 19" relay rack panel, 10½" high.
   - *b.* Overall dimensions including dust covers: Width 19½", height 10½", depth 9½".
   - *c.* Weight including dust covers: 35 lbs.

C. TUBE COMPLEMENT (both units).

1 - OA3	2 - 6AS7G
2 - 2C51/396A	1 - 6V6GT/G
1 - 5R4GY	1 - 6X5GT/G
1 - 543-A (Selected 6AK5)	2 - 12AX7
4 - 543-B (Selected 6AK5)	1 - 545-A (Selected 3S6/5)
2 - 6AU6	

D. ACCESSORIES.

1. Adapter	"BNC" to "N"	BRC Type 504-A
2. Adapter (53-ohm 6db "T" pad)	"BNC" to "N"	BRC Type 505-B
3. Patching cable, 6 ft.	"BNC" to "BNC"	BRC Type 506-B

II. THEORY OF OPERATION.

A. INTRODUCTION.

The BRC Type 211-A Signal Generator is a precisely calibrated modulated RF signal source. Covering a frequency range from 88 to 140 mc, it is so designed as to operate with exceptionally low distortion and low phase shift between the modulating voltage and the modulated envelop of the carrier.

The frequency of the master oscillator output may be accurately standardized through use of the self-contained crystal monitor.

Metering of both the RF output and the percent modulation is effected by separately rectifying the RF carrier and its modulation component, and using the DC developed to operate the meters. This method of monitoring assures a high degree of monitoring accuracy.

Physically, the 211-A Generator and its Power Supply, 211-AP1, are two separate rack mounting units. These units are shipped in protective dust covers that need not be removed for mounting.

B. RF GENERATOR.

1. Master Oscillator.

The RF generator contains a crystal oscillator and a tunable master oscillator, which may be selected to operate individually or simultaneously. Selection of the desired mode of operation is made by front panel oscillator selector switch S303 (Figure 2) which controls the application of plate voltages at the respective settings.

As described in Section III, paragraph D-3, the master oscillator may be recalibrated on any one of the available harmonics listed in the charts shown on page 13.

A friction clutch is used to mount the master oscillator vernier frequency dial on the tuning shaft. This clutch enables the dial to be mechanically slipped upon the shaft so that the frequency dial may be adjusted to read correctly at the various crystal harmonic frequencies. A lock mechanism detains the dial while it is being slipped.

2. Buffer-Doubler.

The output of the master oscillator is fed to a 6AK5 pentode V202 (Figure 1) used as a class C buffer-doubler. The plate tank of this stage is tuned by section "B" of the gang capacitor C204 (Figure 9). Doubling in this stage permits operation of the oscillator at a lower frequency. It also provides the isolation necessary to prevent frequency modulation of the master oscillator when the RF carrier is amplitude modulated in the output-doubler stage.

3. Crystal Oscillator.

Front panel switch S201 (Figure 2) connects either of two crystals, 13.7625 mc or 14.3625 mc, into the grid circuit of the electron coupled 6AK5 pentode oscillator V205. Inductor L209 (Figure 9) tuned mid-way between the two frequencies, serves as the oscillator plate impedance at both frequencies.

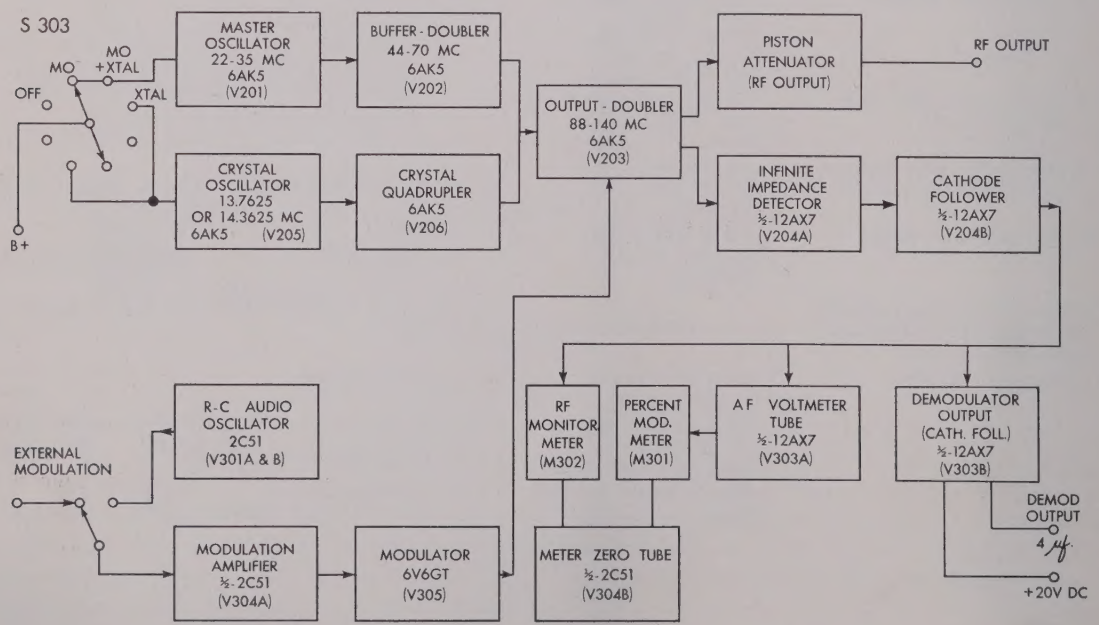
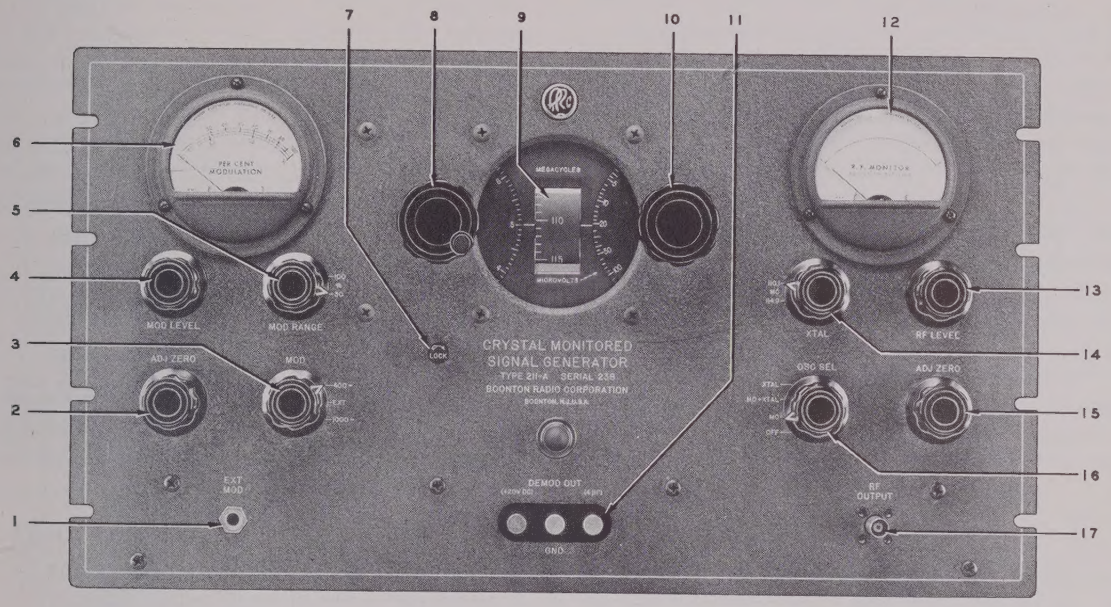


Fig. 1. Basic Elements of Type 211-A Signal Generator



1. EXTERNAL MODULATION INPUT JACK
2. MODULATION METER ZERO ADJUSTMENT
3. MODULATION SELECTOR SWITCH
4. MODULATION LEVEL CONTROL
5. MODULATION METER RANGE SWITCH
6. PERCENT MODULATION METER
7. DIAL LOCK
8. VERNIER FREQUENCY DIAL
9. MAIN FREQUENCY DIAL
10. R.F. OUTPUT ATTENUATOR
11. DEMODULATOR OUTPUT TERMINALS
12. R.F. MONITOR METER
13. R.F. LEVEL CONTROL
14. CRYSTAL SELECTOR SWITCH
15. R.F. MONITOR METER ZERO ADJUSTMENT
16. OSCILLATOR SELECTOR SWITCH
17. R.F. OUTPUT JACK

Fig. 2. Panel View of Type 211-A Signal Generator

4. Crystal Frequency Quadrupler.

This 6AK5 Pentode quadrupler V206 (Figure 1) feeds into the buffer-doubler plate tank, and thus uses the same output stage V203 as the buffer-doubler V202. Dual use of the output system requires that the tuning capacitor C204 (Figure 9) be tuned for peak output at approximately 110.1 mc or 114.9 mc when the crystal oscillator section is in use.

5. Output-Doubler.

A common plate tank is coupled to both the buffer-doubler V202 and the crystal frequency quadrupler V206, and provides a means of feeding signals from either or both circuits into the output doubler V203. This second 6AK5 pentode class C doubler functions both as a modulator and an RF power output stage. By using screen modulation, full 100% is attained without appreciable distortion, and the power required for modulation is reduced as compared to that necessary in the case of plate modulation. The use of audio frequency degeneration in the screen circuit also effects a reduction in modulation distortion.

C. RF OUTPUT SYSTEM.

A piston type attenuator, inductively coupled to the plate tank of the output-doubler V203 (Figure 1) is used to control the RF output of the 211A Generator. Continuously variable attenuation is provided by means of a piston driven by a rack and gear assembly.

Referring to Figure 3, the voltage 2E induced in the pickup loop L206A can be shown to be a function of the tank voltage E_T across L206B and the coefficient of coupling K between L206B and L206A. K is controlled by the position of the piston in the attenuator while E_T is monitored by the RF monitor meter.

The 211-A attenuator dial is calibrated to read E, where 2E is the voltage induced in the loop L206A (Figure 3A). Therefore, since the internal impedance of the generator is 50 ohms, the voltage *across* a 50-ohm load connected to the panel jack may be read directly on the dial. The voltage developed *across* an external load of any value may be determined by applying Ohm's law.

$$\text{where } E_L = 2E\frac{Z_L}{50 + Z_L}$$

E_L = voltage across Load

Z_L = load impedance

This relation is true since the 50-ohm internal impedance of the generator is made equal to the

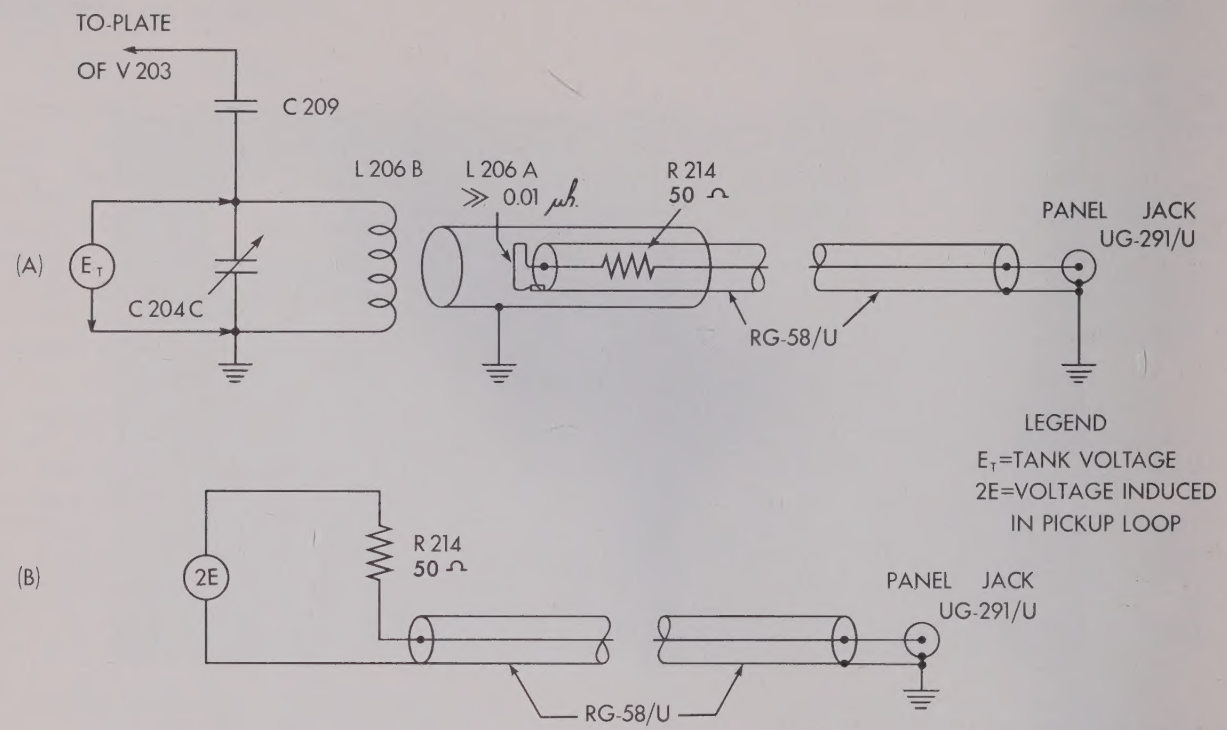


Fig. 3. RF Output System

characteristic impedance of the transmission line between the source and the load. For proof of this, refer to the appendix.

For a discussion of accessories and receiver matching techniques, refer to Section II, H, - Output Connections and Matching.

D. DEMODULATION AND METERING CIRCUITS

1. Detector and Cathode Follower.

The demodulator, consisting of one-half of a 12AX7 high-mu double triode V204A (Figure 1) operates as an "infinite impedance detector" and is connected across the plate tank of the output-doubler stage V203. The output of the demodulator is direct-coupled to the second half of the 12AX7, V204B, which is operated as a cathode follower to reduce the output impedance to a value allowing transmission of the higher audio frequencies through an RF filter section (See Figure 9) without excessive phase shift.

2. Demodulator Output.

After being passed through the RF filter, the demodulated tank voltage is placed across the "DEMOD OUTPUT" terminals by means of a second cathode follower V303B. This triode affords sufficient isolation to permit the connection of a minimum load of 20k ohms without affecting the metering circuits. Since the phase shift introduced by the entire demodulation system is negligible, the phase of the audio component of the carrier may be monitored by comparing the phase of the demodulated output voltage appearing on the "20 V DC" post to the voltage of the modulating source.*

The "4 MF" post provides a means of connection for impedance loads lower than 20k ohms, such as ear phones used for aural monitoring.

3. AF Voltmeters and Percent Modulation Meter.

Meter M301 (Figure 1) and high-mu triode V303A together form a circuit which operates as a peak reading VTVM to indicate the PER CENT MODULATION of the carrier. The input to this VTVM consists of the AF component of the demodulated carrier. The percentage of modulation is determined by comparing this AF component to the entire output of the demodulator V204, which appears as a fixed reference voltage when the needle of the RF MONITOR meter is set on the red line.

Two ranges (0-30% and 30-100%) of PER CENT MODULATION are available through use of the meter calibrating resistor network. Selection of either of these ranges is made by switch S301 (Figure 2).

**External circuits which are so sensitive to the dc at this post as to require dc isolation must be provided with such isolation as will introduce negligible phase shift at the modulating frequency.*

4. RF Monitor Meter.

The RF Monitor meter M302 is a high impedance DC voltmeter which indicates the voltage developed by the infinite impedance detector V204A, and passed through the cathode follower V204B. The "red line" voltage read by this meter is standardized at 26 V DC in all instruments. This operation at a standard level greatly facilitates RF unit replacement, and contributes to uniformity of generators.

5. Meter Zero Tube.

Both the Percent Modulation meter M301 and the RF Monitor meter M302 are connected in cathode circuits of vacuum tubes and thus require a source of "bucking" voltage. This is developed across the cathode load resistor of the meter zero tube V304B (half-2C51), and provides automatic compensation for the effects of filament or plate voltage changes. Adjustment is provided by potentiometers P310 (RF Monitor meter) and P309 (Percent Modulation meter).

E. MODULATOR.

1. Modulation Amplifier and Modulator.

This two stage audio amplifier V304A and V305, utilizing half of a 2C51 and a 6V6GT/G, is conventional except for the use of a resistive output load and for the design of the overall inverse feedback network. Both of these differences were necessitated by the rigid design specifications relating to distortion, flatness and phase shift.

Connection to an external modulation input source is made through either the front panel "EXT MOD" phone jack J302 (Figure 2) or jack J301 (Figure 4) on the rear of the chassis. Insertion of a phone plug in jack J302 disconnects J301 from the amplifier input, but J302 is not affected by a phone plug in J301.

Phase shift at both low and high audio frequencies is compensated by the incorporation of frequency selective phase shifting feedback networks. A factory adjustment of P306 (Figure 4) reduces the 30 cycle phase shift to zero. Phase compensation at higher audio frequencies is provided by C308 (Figure 9).

The output level of the modulator is controlled by the MOD LEVEL control potentiometer P305 (Figure 2) which is effective on both internal and external (EXT) modulation inputs.

2. A high resistance bleeder across the 575V supply provides the DC potential required for the screen of the output-doubler V203 (Figure 1). Adjustment of the DC level is made with P307 (Figure 2), the RF level control. By varying the screen voltage of the output-doubler this control adjusts the RF output voltage to a fixed value against which the percent modulation voltage is referenced. This fixed value is in-

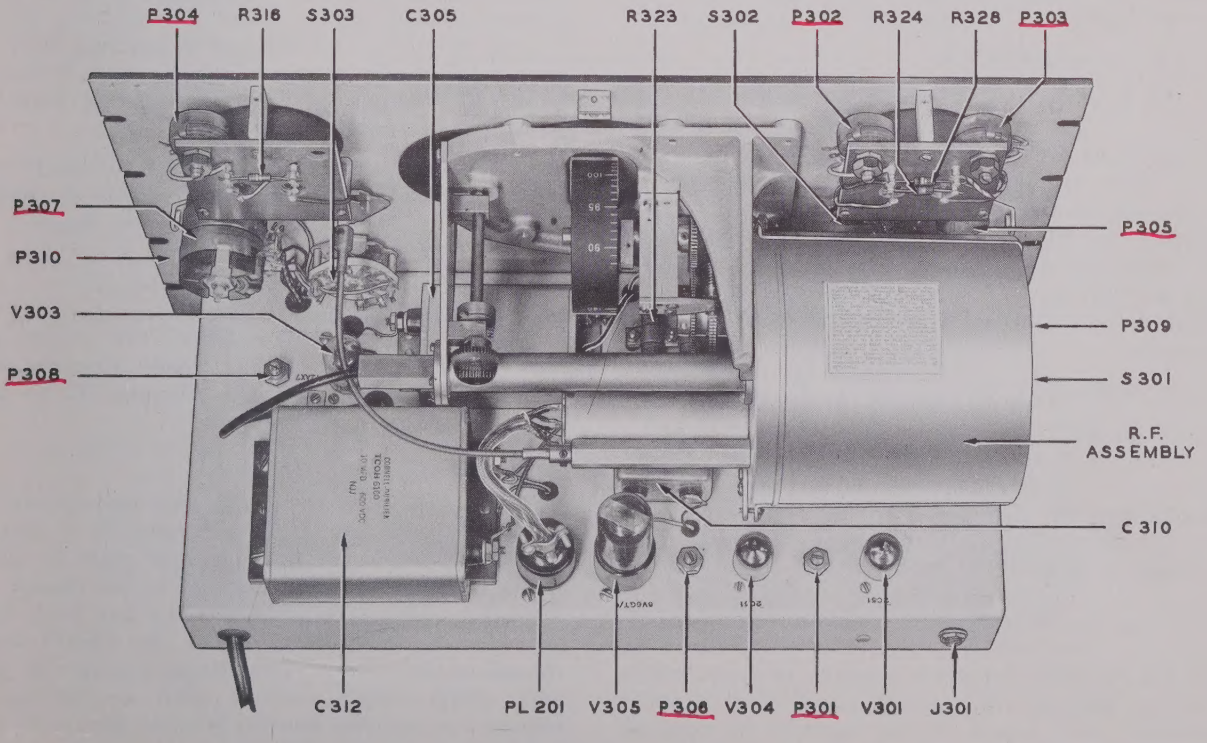


Fig. 4. Top View of Type 211 A Signal Generator

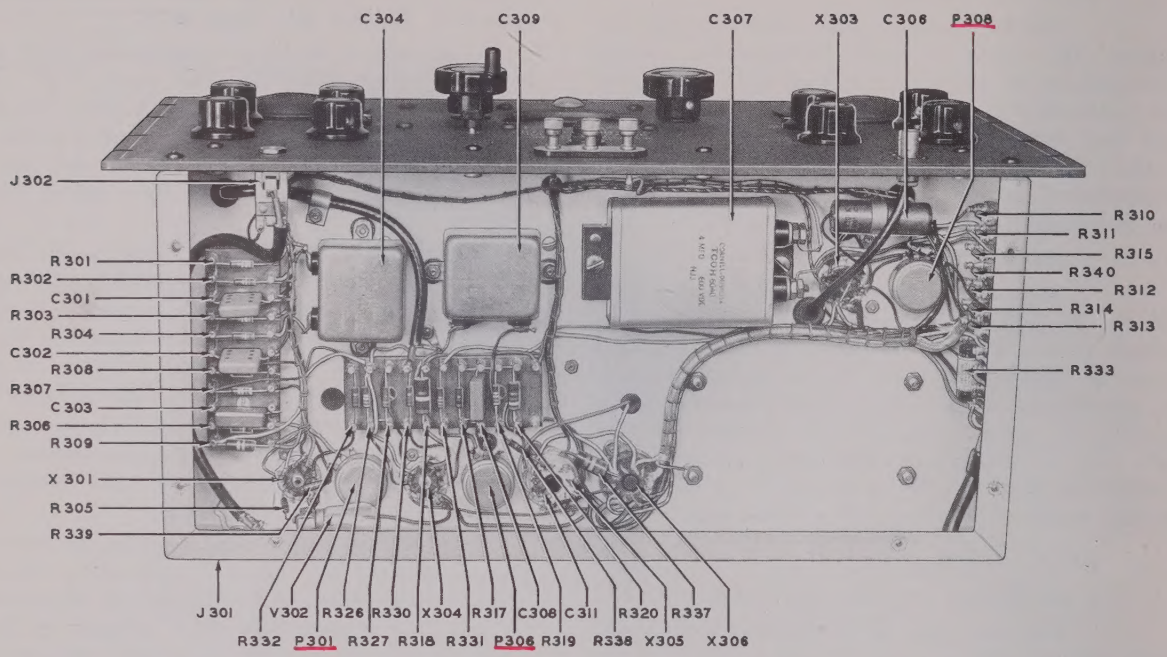


Fig. 5. Sub-Chassis View of Type 211-A Signal Generator

dicated by the pointer of the RF MONITOR meter M302 (Figure 2) being set at the red line. Therefore, the PERCENT MODULATION meter M301 will indicate the true percentage of modulation only when the RF MONITOR meter pointer is set at the red line.

F. AF GENERATOR.

1. R-C Audio Oscillator.

The two halves of a 2C51 twin triode V301 A and B are connected in a conventional Wien bridge R-C audio oscillator circuit (Figure 8). Selection of the oscillation frequency is made by MOD switch S301 (Figure 3). Potentiometer P301 sets the output level by controlling the feedback. The output is available for use with the modulation amplifier by turning the MOD switch S301 to either 400 or 1000 cycles as desired.

G. POWER SUPPLY - TYPE 211-AP1.

1. 200V Supply.

a. Rectifier - Filter System.

Approximately 350V of partly filtered unregulated DC is supplied to the regulator section by the 6X5GT tube V102 (Figure 10) and its associated components.

b. Regulator Section.

The 6AS7G "series" tube V106 serves as an automatically controlled variable resistance which acts to maintain its cathode at a 200-V positive potential with regard to the negative terminal of the supply.

The automatic control bias for V106 is provided by a bridge and amplifier circuit using the screen of the 6AU6 amplifier tube V107 as the control element. Resistors R-111 and R-112 (Figure 10) serve the dual purpose of providing the proper DC operating potential for the screen of V107, and of selecting the portion of the change voltage appearing across V106 required for injection on the screen grid of V107 to maintain bridge balance with 200 V output.

Adjustment of the output voltage to exactly 200 V is accomplished by varying P-102 (Figure 6) located at the rear of the 211-AP1 Power Supply chassis.

2. 575V Supply.

a. Rectifier - Filter System.

The 5R4GY rectifier V101 (Figure 9) and its associated components supply approximately 880 V of rectified and partly filtered DC to the regulator section.

b. Regulator Section.

Circuit theory and general operation are the same for this regulator V104 as for the 200 V supply. Adjustment of the output voltage is made by P101 (Figure 6) also located at the rear of the chassis. A thermal type time delay relay K101 has been connected in the filament circuit of the 5R4GY high voltage rectifier V101. This delays operation of the high voltage supply until all tubes are thoroughly warmed up, and thus prevents possible damage to the generator or power supply by initial voltage surges.

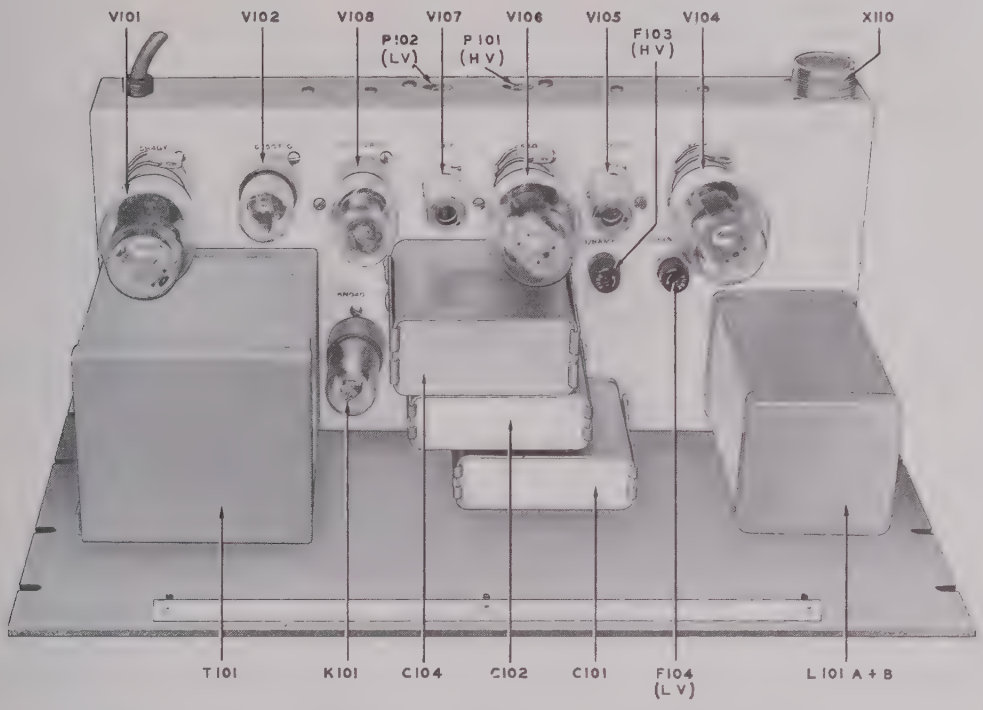


Fig. 6. Top View of Type 211-AP1 Power Supply

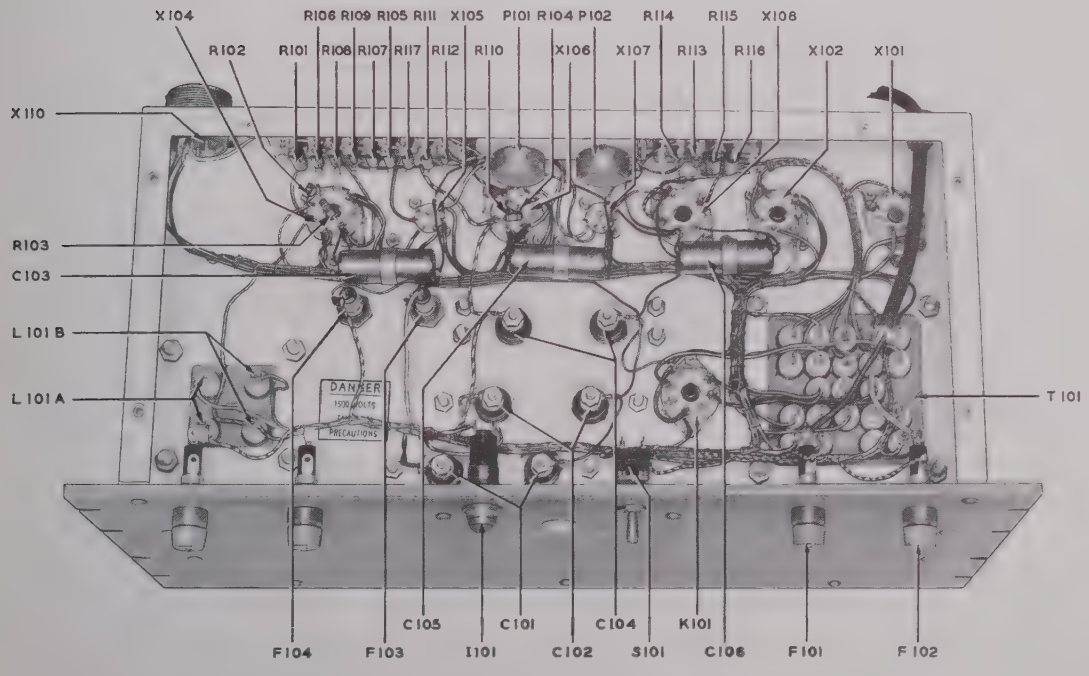


Fig. 7. Sub-Chassis View of Type 211-AP1 Power Supply

H. OUTPUT CONNECTIONS AND MATCHING.

1. Matching.

The method of connecting the load to the generator must be carefully considered to insure proper interpretation of results, and to this end the following discussion is offered as an aid to the user:

It is convenient to represent a signal source in terms of its *open circuit voltage* and its *internal impedance.* Thus a signal source or an antenna can be represented as in Figure 8-a. To simplify the discussion, the source and load impedance will be considered as wholly resistive.

For purposes of sensitivity rating, the input to a receiver might be defined initially in terms of the open circuit voltage of the source, "E", or the voltage actually across the receiver terminals. The Institute of Radio Engineers has chosen the former method and defined receiver input in terms of the open circuit voltage of the source.

The impedance of the signal source employed to test receivers should be equal to the impedance of the antenna with which the receiver is designed to operate. Note that in this case the voltage actually across the receiver input terminals is E/2 (Receiver input impedance equal to source impedance).

2. Accessories.

For physically connecting the generator to a load, the following accessories are used:

a. BRC Type 504-A Adapter (BNC to N).

The Type 504-A Adapter provides a physical transition from type "BNC" to type "N" connectors (See Figure 8-d). If the 211-A RF output is connected through this adapter directly to a 50-ohm receiver input, it should be noted that since the open circuit voltage is twice that indicated by the attenuator dial, the equivalent receiver input becomes twice the indicator dial reading.

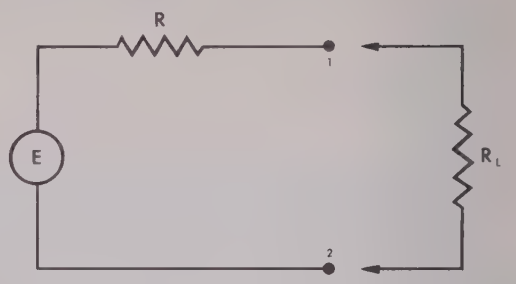
b. BRC Type 505-B 6 db T-pad (BNC to N)

This pad is used as a dummy antenna in testing unbalanced receivers with a 50-ohm input as shown in Figure 8-b.

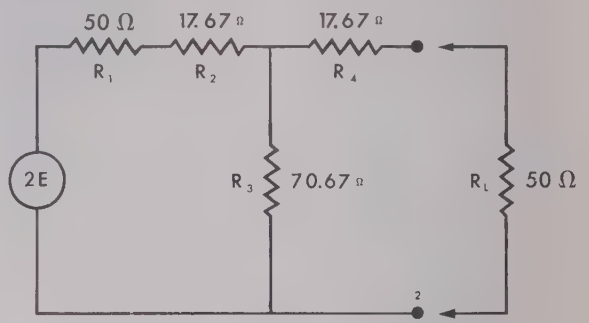
The open circuit voltage appearing across terminals 1 and 2 is by Ohm's law equal to E, half of the source voltage. Applying Thevinin's theorem, the equivalent circuit of Figure 8-c is obtained, and the attenuator dial of the 211-A reads receiver input directly.

c. BRC Type 506-B Patching Cable (BNC to BNC)

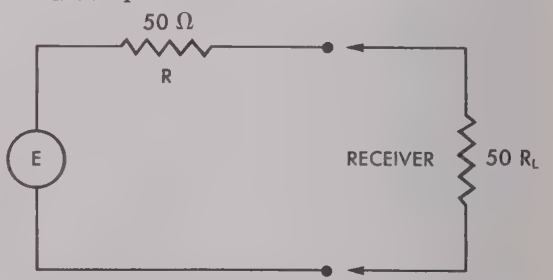
This cable consists of a 6 ft. length of RG-58/U cable provided with UG-88/U BNC connectors at each end. If the 211-A RF output is connected through this cable directly to a 50-ohm receiver input, it should be noted that since the open circuit voltage is twice that indicated by the attenuator dial, the equivalent receiver input becomes twice the indicator dial reading.



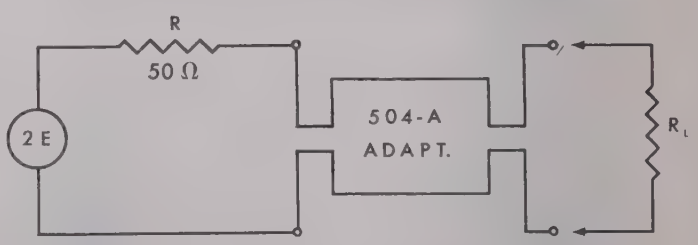
(a) Representation of a signal source or antenna in terms of the open circuit voltage and internal impedance.
E=open circuit output voltage
R=impedance looking into terminals 1 & 2
R_L=load impedance



(b) 211-A Generator with Type 505-B 6 db T Pad.
E=211-A attenuator dial reading-open circuit output voltage
R_1=internal impedance of generator
R_L=load impedance
$R_{2,3,4}$=pad resistors



(c) Equivalent circuit for (B) above.
R=signal source (antenna or generator impedance)
R_L=load (antenna impedance of receiver)



(d) 211-A Generator with Type 504-A Adapter.
E=211-A attenuator dial reading
2E=open circuit output voltage
R_L=load impedance.
R=internal impedance of generator.

Fig. 8. Accessories

III. OPERATING INSTRUCTIONS.

A. INSTALLATION.

Carefully remove the generator and power supply from their respective packing cartons and inspect for possible damage in shipment. IT IS IMPORTANT THAT THE MANUFACTURER BE NOTIFIED IMMEDIATELY IF ANY DAMAGE IS BELIEVED TO HAVE BEEN CAUSED IN TRANSIT.

The Type 211-A Generator and Type 211-AP1 Power Supply may be rack mounted if desired. The dust covers need not be removed for this mounting, and either unit may be mounted above the other as preferred.

When line voltage conditions are such that the average voltage available is 10V or more *above* or *below* the nominal 115V for which the power supply is connected at the factory, the primary tap connection of the power transformer should be changed appropriately. To make this change, unsolder the lead connected to terminal 10 of the power transformer T101 (Figure 7) and solder it to terminal 9 if the line voltage is 105V, or to terminal 7 if the line voltage is 125 V. It is recommended that any such change be noted immediately on a tag attached to the power input cord, thus providing a record of the change and a warning as to the nominal line input voltage for which the supply is connected.

Connect the generator cable terminated in an AN connector to the receptacle located in the rear of the power supply cabinet and plug in the power cord at a suitable 115 volt, 50-60 cycle outlet. Turn the power switch of the power supply to the ON position. Both generator and power supply pilot lights should light. A 40-second time delay relay is incorporated in the power supply to delay operation of the high voltage rectifier until all other tubes have reached normal operating temperatures.

B. PRELIMINARY OPERATIONAL CHECKS

As a preliminary indication that the instrument is operating properly, the following checks should be made (see Figure 2):

1. With the OSC SEL switch (16) OFF, see that the RF MONITOR meter (12) can be set to zero with the ADJ ZERO control (15).
2. Turn the OSC SEL switch to MO and, while tuning throughout the range of 88 to 140 mc, ascertain that the RF MONITOR meter can be set to the red calibration line by means of the RF LEVEL control (13).
3. Change the setting of the OSC SEL switch to XTAL, and turn the XTAL switch (14) to 110.1. Tune the vernier frequency knob in the region of 110.1 mc, then see that the RF MONITOR meter (12) can be set to the red line by means of the RF LEVEL control.
4. Repeat step 3 with the XTAL switch on 114.9 and tuning to peak near 114.9 mc on the frequency dial.
5. With the OSC SEL switch turned to OFF, and with the MOD LEVEL control (4) turned completely counter-clockwise, set the PERCENT MODULATION meter (6) to zero using the ADJ ZERO control (2).
6. Set the OSC SEL switch to MO, the MOD switch (3) to 400 cycles, and the MOD RANGE switch (5) to 100%. Turn the MOD LEVEL control clockwise and determine that the PERCENT MODULATION meter can be set to read 100%.
7. Repeat step 6 with the MOD switch on 1,000 cycles.
8. Set the MOD RANGE switch to the 30% position and repeat steps 6 and 7.

C. SETUP FOR OPERATION.

Before using the generator for testing it is necessary to perform the following setup operations (see Figure 2).

1. Switch the power supply to ON (S101, Figure 7).
2. Turn the MOD LEVEL (4) and the RF LEVEL (13) controls fully counter-clockwise.
3. Allow a few minutes for warmup and to insure that the time delay relay has functioned.
4. Switch the OSC SEL switch (16) to OFF. Set the RF MONITOR meter to zero, using the ADJ ZERO control (15) at the lower right side of the panel.
5. With the OSC SEL switch still in the OFF position, set the PERCENT MODULATION meter to zero using the ADJ ZERO control (2) at the lower left side of the panel.
6. Standardize the master oscillator as described in paragraph III D.3, when the generator is first placed in service or whenever the dial has been mechanically displaced.

D. OPERATION.

1. Master Oscillator.

a. Using the VERNIER FREQUENCY DIAL (8), tune to the desired RF output frequency.

b. Turn the OSC SEL switch (16) to MO.

c. Set the RF MONITOR meter to the red line using the RF LEVEL control (13). NOTE: *The RF MONITOR meter must always be at the red line whenever a reading of the percentage modulation is made (see paragraph II.E.2).*

d. With the MOD switch (3), select the desired modulation (400 or 1,000 cycles internal or 30 to 11,000 cycles external).

e. Adjust the MOD RANGE switch (5) for the appropriate meter range.

f. Using the MOD LEVEL control (4), adjust to the required percentage of modulation.

g. Set the MICROVOLTS (Attenuator) dial (10) to the desired RF output level.

h. If the RF output frequency is changed it may be necessary to re-adjust the RF LEVEL control to maintain a reading of "red line" on the RF MONITOR meter. The MOD LEVEL control may also require re-setting to hold the desired percentage of modulation as read on the PERCENT MODULATION meter (6).

2. *Crystal Oscillator.*

a. Turn the OSC SEL switch to XTAL.

b. Set the XTAL switch to the desired crystal output frequency (110.1 mc or 114.9 mc).

c. With the vernier frequency dial, tune for maximum reading on the RF MONITOR meter (at the approximate crystal output frequency).

d. Adjust the RF LEVEL control for a reading of "red line" on the RF MONITOR Meter.

e. With the MOD switch (3) select the desired modulation.

f. Adjust the MOD RANGE switch (5) for the appropriate meter range.

g. Using the MOD LEVEL control (4), adjust to the desired percentage of modulation.

h. Set the MICROVOLTS (attenuator) dial (10) to the desired RF output level.

3. *Master Plus Crystal Oscillator (see Section II. B.1).*

Table I on page 13 shows various beat points that occur when the 110.1 mc crystal switch position is in use. Other points may be located and identified, but those given should suffice for most applications. The approximate output at each beat and its derivation are also shown in the table. As an example, at 100.925 mc the 11th harmonic of the 13.7625 mc crystal beats with the 6th harmonic of the master oscillator, and produces a beat signal which measures approximately 50 millivolts.

Table II on page 13 lists beats obtainable when using the 114.9 mc crystal switch position.

a. Turn the OSC SEL switch to MO, and tune to the approximate frequency at which standardization is to be performed.

b. Using the RF LEVEL control, set the RF MONITOR meter to "red line". Turn the MOD RANGE switch to 100%, and the MOD switch to EXT.

c. Switch the OSC SEL control to MO-XTAL; the XTAL switch to either 110.1 or 114.9 mc, whichever provides the desired check points.

d. Connect a pair of earphones across the "4 μf" and "GND" DEMOD OUT posts.

e. Re-tune slightly until an audible beat note can be heard in the phones, and then set (8) in Figure 2 to zero beat. Compare the frequency indicated by the generator with that given on the chart, and note the extent and direction of error.

f. Rotate the vernier frequency control to indicate the exact kilocycle calibration shown on the chart.

g. Lock the vernier *dial* in this position by turning the LOCK knob clockwise until tight; then rotate the vernier *knob* (thus slipping the shaft within the dial assembly) in the direction required to re-tune to the beat frequency previously obtained (in step e.).

h. Release the LOCK knob.

i. Next verify the correctness of the beat point selected, by tuning to at least two of the adjacent charted beats which should occur on the dial within a few kilocycles of the charted frequencies.

4. *In connecting the Type 211-A Generator to a load under test, certain precautions as to matching the load to the generator must be observed for accurate results. For a brief discussion of matching and a description of the accessories to be used to connect the generator to a load, see paragraph II. H., Output Connections and Matching.*

NOTE: A third useful crystal controlled output frequency of 137.625 mc may be obtained if, when using the 110.1 mc crystal position, the generator is tuned to approximately 137.625 mc. For this output frequency the tube normally used as a quadrupler is operating as a quintupler.

Ref. Desig.	HP Part No.	TQ	RS	Description	FSCM	Mfg. Part No.
C101,102	0160-0757	4	1	C: fxd paper 4μF 10% 1K vdcw	56289	170P3013
C103	0160-0001	4	1	C: fxd my 0.1μF 10% 600 vdcw	56289	160P10496
C104	0160-0758	2	1	C: fxd paper 10μF 10% 600 vdcw	14655	TCO-1600X
C105,106	0160-0001	4	1	C: fxd my 0.1μF 10% 600 vdcw	56289	160P10496
C201	0160-0427	2	1	C: fxd mica 1000pF 10% 500 vdcw	72982	652-005
C202,203	0160-0441	7	2	C: fxd cer 47pF 5% 500 vdcw rad	72982	315000
C204A	00202-60030	1	1	stator only	28480	00202-60030
C204B, C	00211-60048	2	0	stator only	28480	00211-60048
C204A,B,C	00211-60054	1	0	rotor only	28480	00211-60054
C205	0160-0823	2	1	C: fxd cer 5pF 5% 500 vdcw	00656	N-750
C206	0160-0441			C: fxd cer 47pF 5% 500 vdcw rad	72982	31500
C207	0160-0426	2	1	C: fxd mica 500pF 10% 500 vdcw	72982	653-002
C208,209	0160-0441			C: fxd cer 47pF 5% 500 vdcw rad	72982	31500
C210	0160-0425	1	1	C: fxd mica 250pF 10% 500 vdcw	72982	653-002
C211	0160-0826	2	1	C: fxd cer 15pF 2% 500 vdcw	00656	*obd
C212	0160-0823	2	1	C: fxd cer 5pF 5% 500 vdcw	00656	N-750
C213	0160-0825	1	1	C: fxd cer 10pF 10% 500 vdcw	72982	82015
C214	0160-0732	1	1	C: fxd mica 500pF 10% 500 vdcw	72982	653-002
C215	0121-0065	2	1	C: var cer 3-12pF	72982	503000COPO17R
C216	0160-0826			C: fxd cer 15pF 2% 500 vdcw	00656	*obd
C217	0160-0827	1	1	C: fxd mica 150pF 5%	72982	665-001
C218	0160-0427			C: fxd mica 1000pF 10% 500 vdcw	72982	652-005
C219	0160-0441			C: fxd cer 47pF 5% 500 vdcw rad	72982	315000
C221-226	0160-0459	12	3	C: fxd mica 250μF 10% 500 vdcw	72982	654-005
C227-229	0160-0424	3	1	C: fxd mica 100pF 10% 500 vdcw	72982	654-006
C230-232	0160-0459			C: fxd mica 250μF 10% 500 vdcw	72982	654-006
C233-235	0160-0422	3	1	C: fxd mica 33pF 10% 500 vdcw	72982	654-006
C236-238	0160-0459			C: fxd mica 250μF 10% 500 vdcw	72982	654-006
C239	0160-0441			C: fxd cer 47pF 5% 500 vdcw rad	72982	315000
C240	0121-0065			C: var cer 3-12pF	72982	503000COPO17R
C241	0160-0438	1	1	C: fxd cer 22pF 2% 500 vdcw	72982	301600COPO220G
C242-244	0121-0072	3	1	C: var glass 0.5 - 3.0pF	07115	680073
C301,302	0140-0018	2	1	C: fxd mica 1000pF 5% 500 vdcw	04062	CM20E102J
C303	0160-0832	2	1	C: fxd mica .01μF 2% 300 vdcw	04062	604L
C304	0160-0751	1	1	C: fxd paper 1.0μF 10% 600 vdcw	14655	DYR6100
C305	0170-0036	2	1	C: fxd paper 4μF 10% 400 vdcw	56289	P108166PTM
C306	0160-0001			C: fxd my 0.1μF 10% 600 vdcw	56289	160P10496
C307	0170-0036			C: fxd paper 4μF 10% 400 vdcw	56289	P108166PTM
C308	0140-0086	1	1	C: fxd mica 2000pF 5% 500 vdcw	04062	CM20E102F
C309	0160-0751			C: fxd paper 1.0μF 10% 600 vdcw	14655	DYR6100
C310	0160-0752	1	1	C: fxd paper 2.0μF 10% 600 vdcw	14655	DYR6200
C311	0160-0440	1	1	C: fxd cer 47pF 5% 500 vdcw ax	72982	31500S2L0470J
C312	0160-0758			C: fxd paper 10μF 10% 600 vdcw	14655	TCO-6100X
C313	0160-0832			C: fxd mica .01μF 2% 300 vdcw	04062	604L
F101	2110-0303	1	10	fuse 3A 250V	47900	312003
F102	2110-0006	1	10	fuse 2A 250V slo-blo	75915	312002
F103,104	2110-0318	2	20	fuse 1/8A 125V	75915	312002
I101,301	1450-0433	2	2	lamp, incandescent clear	08807	47
J301	1251-0205	1	1	phone jack	82389	2J-1432 or #11
J302	1251-0066	1	1	connector, phone jack	82389	2J-1339 or #12A
K101	0490-0048	1	1	relay time delay 6N030	70563	6N030
L101A,B	9110-0091	1	1	choke deal filter 2 x 10H	73386	16072
L201	9140-0223	4	1	coil fxd 35μH	11307	85590
L202A,B	00211-60049	1	0	M.O. tank assembly	28480	00211-60049
L203	9140-0223			coil, fxd 35μH	11307	85590
L204	00211-60050	1	0	first doubler tank assembly	28480	00211-60050
L205	9140-0224	1	1	coil, fxd 5μH	11307	A-85589-B
L206	00211-60052	1	0	final doubler tank assembly	28480	00211-60052
L207	5080-1706	1	1	choke, 10μH	11307	A-85593-F
L208	9140-0223			coil, fxd 35μH	11307	85590

* order by description

Ref. Desig.	HP Part No.	TQ	RS	Description	FSCM	Mfg. Part No.
L209	00211-60051	1	0	crystal oscillator tank assembly	28480	00211-60051
L210	9140-0223			coil, fxd 35μH	11307	85590
L211-216	5080-1701	10	2	choke, 50μH	11307	A-85592-H
L217, 218	00250-80024	2	1	choke, 10μH	28480	00250-80024
L219-222	5080-1701	10		choke, 50μH	11307	A-85592-H
M301	1120-0323	1	1	meter, 100μA modulation	40931	*obd
M302	1120-0322	1	1	meter, 100μA RF monitor	93331	04009
P101, 102	2100-0472	4	1	R: var 100KΩ 10% 2.25w	01121	type J
P301	2100-0904	1	1	R: var 2.5KΩ 10% 2w	01121	type J
P302	2100-0472			R: var 100KΩ 10% 2.25w	01121	type J
P303	2100-0256	1	1	R: var 25KΩ 10% 2.25w	01121	type J
P304	2100-0860	1	1	R: var 250KΩ 2w	01121	type J
P305	2100-0905	1	1	R: var 100KΩ 10% 2w	01121	type J
P306	2100-0472			R: var 100KΩ 10% 2.25w	01121	type J
P307	2100-0960	1	1	R: var 40KΩ/40K 10%	12697	series 10
P308	2100-0027	1	1	R: var 10KΩ 10% 2.25w	01121	type J
P309, 310	2100-0732	2	1	R: var 500Ω 10% 2.25w	01121	type J
PL301	1251-0441	1	1	connector, straight	02660	MS-3106B-22-24P
R101	0692-8235	1	1	R: fxd, comp 82KΩ 5% 2w	01121	HB-8235
R102	0689-1055	2	1	R: fxd, comp 1MΩ 5% 1w	01121	GB-1055
R103, 104	0686-4715	2	1	R: fxd, comp 470Ω 5% 1/2w	01121	EB-4715
R105	0689-2445	1	1	R: fxd, comp 240KΩ 5% 1w	01121	GB-2445
R106	0689-2735	1	1	R: fxd, comp 27KΩ 5% 1w	01121	GB-2735
R107	0689-3345	1	1	R: fxd, comp 330KΩ 5% 1w	01121	GB-3345
R108	0689-2745	2	1	R: fxd, comp 270KΩ 5% 1w	01121	GB-2745
R109	0686-1045	11	3	R: fxd, comp 100KΩ 5% 1/2w	01121	EB-1045
R110	0686-6845	2	1	R: fxd, comp 680KΩ 5% 1/2w	01121	EB-6845
R111	0689-8235	1	1	R: fxd, comp 82KΩ 5% 1w	01121	GB-8235
R112	0686-2235	1	1	R: fxd, comp 82KΩ 5% 2w	01121	EB-2235
R113	0689-2745			R: fxd, comp 270KΩ 5% 1w	01121	GB-2745
R114	0686-1045			R: fxd, comp 100KΩ 5% 1/2w	01121	EB-1045
R115	0770-0006	1	1	R: fxd, comp 15KΩ 10% 1/2w	14674	FP-4
R116				not assigned		
R117	0689-1055			R: fxd comp 1MΩ 5% 1w	01121	GB-1055
R201	0692-1035	2	1	R: fxd comp 10KΩ 5% 2w	01121	HB-1035
R202	0686-1045			R: fxd comp 100KΩ 5% 1/2w	01121	EB-1045
R203	0686-3335	2	1	R: fxd comp 33KΩ 5% 1/2w	01121	EB-3335
R204, 205	0686-1045			R: fxd comp 100KΩ 5% 1/2w	01121	EB-1045
R206	0689-2235	2	1	R: fxd comp 22KΩ 5% 1w	01121	GB-2235
R207	0686-1045			R: fxd comp 100KΩ 5% 1/2w	01121	EB-1045
R208	0686-4735	4	1	R: fxd comp 47KΩ 5% 1/2w	01121	EB-4735
R209	0689-2235			R: fxd comp 22KΩ 5% 1w	01121	GB-2235
R210	0686-1045			R: fxd comp 100KΩ 5% 1/2w	01121	EB-1045
R211	0686-3335			R: fxd comp 33KΩ 5% 1/2w	01121	EB-3335
R212	0686-1045			R: fxd comp 100KΩ 5% 1/2w	01121	EB-1045
R213	0692-1035			R: fxd comp 10KΩ 5% 2w	01121	HB-1035
R214	0724-0058	1	1	R: fxd car flm 50Ω 1% 1/4w	80631	C-10
R215	0686-1045			R: fxd comp 100KΩ 5% 1/2w	01121	EB-1045
R216	0686-4725	2	1	R: fxd comp 4.7KΩ 5% 1/2w	01121	EB-4725
R217	0686-6825	2	1	R: fxd comp 6.8KΩ 5% 1/2w	01121	EB-6825
R301	0686-3945	2	1	R: fxd comp 390KΩ 5% 1/2w	01121	EB-3945
R302	0686-1545	2	1	R: fxd comp 150KΩ 5% 1/2w	01121	EB-1545
R303	0686-3945			R: fxd comp 390KΩ 5% 1/2w	01121	EB-3945
R304	0686-1545			R: fxd comp 150KΩ 5% 1/2w	01121	EB-1545
R305	0686-1025	2	1	R: fxd comp 1KΩ 5% 1/2w	01121	EB-1025
R306	0686-1045			R: fxd comp 100KΩ 5% 1/2w	01121	EB-1045
R307	0686-4745	4	1	R: fxd comp 470KΩ 5% 1/2w	01121	EB-4715
R308	0686-2215	4	1	R: fxd comp 220Ω 5% 1/2w	01121	EB-2215
R309	0689-1535	1	1	R: fxd comp 15KΩ 5% 1w	01121	GB-1535
R310	0686-4735			R: fxd comp 47KΩ 5% 1/2w	01121	EB-4735

ef. Desig.	HP Part No.	TQ	RS	Description	FSCM	Mfg. Part No.
R311	0686-2245	2	1	R: fxd comp 220KΩ 5% 1/2w	01121	EB-2245
R312	0686-6845	2	1	R: fxd comp 680KΩ 5% 1/2w	01121	EB-6845
R313, 314	0686-4735			R: fxd comp 47KΩ 5% 1/2w	01121	EB-4735
R315	0686-4725			R: fxd comp 4.7KΩ 5% 1/2w	01121	EB-4725
R316	0686-2245			R: fxd comp 220KΩ 5% 1/2w	01121	EB-2245
R317	0686-1025			R: fxd comp 1KΩ 5% 1/2w	01121	EB-1025
R318	0692-1545	1	1	R: fxd comp 150KΩ 5% 2w	01121	HB-1545
R319	0686-4745			R: fxd comp 470KΩ 5% 1/2w	01121	EB-4745
R320	0689-2415	1	1	R: fxd comp 240Ω 5% 1w	01121	GB-2415
R321				not assigned		
R322	0815-0032	3	1	R: fxd ww 2500Ω 5% 10w	56289	466E2525
R323	0815-0041	1	1	R: fxd ww 40KΩ 10w	56289	456E4035
R324	0686-1015	1	1	R: fxd comp 100Ω 5% 1/2w	01121	EB-1015
R325				not assigned		
R326	0686-4745			R: fxd comp 470KΩ 5% 1/2w	01121	EB-4745
R327	0686-6825	2	1	R: fxd comp 6.8KΩ 5% 1/2w	01121	EB-6825
R328	0686-1045			R: fxd comp 100KΩ 5% 1/2w	01121	EB-1045
R329	0686-4745	4	1	R: fxd comp 470KΩ 5% 1/2w	01121	EB-4745
R330	0686-2215			R: fxd comp 220Ω 5% 1/2w	01121	EB-2215
R331	0686-6835	1	1	R: fxd comp 68KΩ 5% 1/2w	01121	EB-6835
R332	0686-2215	4	1	R: fxd comp 220Ω 5% 1/2w	01121	EB-2215
R333	0812-0085	1	1	R: fxd ww .64Ω 5% 4w	83604	ALA5/8
R334				not assigned		
R335, 336	0815-0032	3	1	R: fxd ww 2500Ω 5% 10w	56289	466E2525
R337	0692-2235	1	1	R: fxd comp 22KΩ 5% 2w	01121	HB-2235
R338	0686-2215			R: fxd comp 220Ω 5% 1/2w	01121	EB-2215
339	0686-2725	1	1	R: fxd comp 2.7KΩ 5% 1/2w	01121	EB-2725
340	0686-1035	1	1	R: fxd comp 10KΩ 5% 1/2w	01121	EB-1035
S101	3101-0003	1	1	toggle switch	04009	*obd
S201	00211-80002	1	1	switch, crystal	28480	00211-80002
S301	3100-0811	1	1	switch, rotary 1 sect 3 pos	71590	PA279-092
S302	3100-0810	1	1	switch, rotary wafer type 1460	71590	A-88088-D
S303	3100-0809	1	1	switch, rotary 1 sect 4 pos	71590	A-88088-D
T101	9100-0259	1	1	transformer, power	73386	16072
V101	1930-0007	1	1	electron tube, 5R4GYA	80131	212-5R4GYA
V102	1930-0018	1	1	electron tube, 6X5GT	80131	6X5GT
V103				not assigned		
V104A, B	1932-0018	2	2	electron tube, 6AS7G	86684	GX5GT
V105	1923-0021	2	2	electron tube, 6AU6	86684	215064
V106A, B	1932-0018			electron tube, 6AS7G	86684	GX5GT
V107	1923-0021			electron tube, 6AU6	86684	215064
V108	1940-0006	1	1	electron tube, OA3	86684	215065
V201, 202	1923-0001	5	1	tube, 5654	13688	*obd
V203, 204	1923-0001			tube, 5654	13688	*obd
V204	1932-0030	2	1	electron tube, 12AX7A	86684	12AX7
V205, 206	1923-0001			tube, 5654	13688	*obd
V301A, B	1932-0038	2	2	electron tube, 2C51	94154	2C51
V302	2140-0001	1	1	lamp, incandescent screw base 115V 3w	13688	3S6-5
V303A, B	1932-0030			electron tube, 12AX7A	86684	12AX7
V304A, B	1932-0038			electron tube, 2C51	94154	2C51
V305	1923-0057	1	1	electron tube, 6V6GT	86684	6V6GT
X110	1251-0440	1	1	connector, box receptacle 6 contacts	02660	MS-3102A-22-24
Y201	0410-0086	1	1	crystal, quartz 13.7625mc	74306	4047300
Y202	0410-0087	1	1	crystal, 14.3625mc	28722	CR-7

Ref. Desig.	HP Part No.	TQ	RS	Description	FSCM	Mfg. Part No.
				Miscellaneous		
	00211-00023	1	0	plate stop	28480	00211-00023
	00211-00025	1	0	spring rotor gnd contact	28480	00211-00025
	00211-20001	1	0	drum dial shaft	28480	00211-20001
	00211-60003	1	0	RF unit - complete assembly	28480	00211-60003
	00211-60010	1	0	drive shaft assembly	28480	00211-60010
	00211-60011	1	0	split gear and hub assembly, 108T	28480	00211-60011
	00211-60012	1	0	split gear and hub assembly, 120T	28480	00211-60012
	00211-60013	1	1	RF unit filter w/cable and plug	28480	00211-60013
	00211-60015	1	1	RF unit attenuator assembly	28480	00211-60015
	00211-60055	4	0	spring wiper assembly	28480	00211-60055
				Mechanical Parts		
	0360-0424	1	0	block binding post	28480	0360-0424
	0360-0425	3	0	post, binding	28480	0360-0425
	0370-0023	1	1	knob, 3/4" dia blk 3/16" shaft	28480	0370-0023
	0370-0032	4	1	knob, skirted 1" dia blk 1/4" shaft	28480	0370-0032
	0370-0038	1	1	knob, 1-5/8" dia blk 1/4" shaft	28480	0370-0038
	0370-0097	4	1	knob, skirted	28480	0370-0097
	0370-0141	1	1	knob, 1-5/8" dia blk	28480	0370-0141
	1200-0002	7	2	socket, octal tube	28480	1200-0002
	1200-0019	1	1	socket, 9 pin tube shield base	28480	1200-0019
	1200-0130	1	1	socket, 7 pin tube shield base	28480	1200-0130
	1200-0132	3	1	tube, socket 9 pin min	28480	1200-0132
	1200-0156	1	1	socket, 11 pin	28480	1200-0156
	1220-0043	5	1	shield, tube 1-3/8" high	28480	1220-0043
	1400-0196	4	4	clamp, tube (for 6B4G and 5R4GY)	28480	1400-0196
	1410-0059	30	0	ball bearing, 1/16" dia steel	28480	1410-0059
	1450-0099	2	0	lampholder, red lens	28480	1450-0099
	5020-2206	2	0	coupling	28480	5020-2206
	7100-0350	1	0	RF unit shield can	28480	7100-0350

TABLE I

110.1 mc Crystal Switch Position
(13.7625 mc Crystal)

BEAT FREQUENCY (mc)	APPROXIMATE BEAT INTENSITY (MILLIVOLTS)	DERIVATION OF BEAT FREQUENCY X = crystal, M = Master Oscillator, Numerals indicate order of harmonics
88.080	35	8X-5M
89.456	10	13X-8M
91.750	60	5X-3M
93.585	3	17X-10M
94.371	3	12X-7M
96.337	200	7X-4M
99.090	15	9X-5M
100.925	50	11X-6M
102.236	10	13X-7M
103.219	25	15X-8M
103.983	10	17X-9M
104.595	40	19X-10M
105.512	30	23X-12M
106.168	25	27X-14M
106.659	20	31X-16M
107.042	20	35X-18M
110.100	2400	4X-2M
112.294	10	49X-24M
112.852	15	41X-20M
113.541	15	33X-16M
114.032	25	29X-14M
114.687	10	25X-12M
115.605	40	21X-10M
116.981	40	17X-8M
117.964	10	15X-7M
119.275	50	13X-6M
121.110	5	11X-5M
123.862	250	9X-4M
125.829	10	16X-7M
128.450	50	7X-3M
130.744	50	19X-8M
132.120	50	12X-5M
133.0375	30	29X-12M
133.6929	40	17X-7M
135.790	10	37X-15M
137.625	2200	5X-2M

TABLE II

114.9 mc Crystal Switch Position
(14.3625 mc Crystal)

BEAT FREQUENCY (mc)	APPROXIMATE BEAT INTENSITY (MILLIVOLTS)	DERIVATION OF BEAT FREQUENCY X = crystal, M = Master Oscillator, Numerals indicate order of harmonics
88.794	15	17X-11M
89.367	15	14X-9M
90.279	20	11X-7M
91.920	35	8X-5M
93.356	25	13X-8M
95.750	65	5X-3M
97.665	5	17X-10M
98.486	10	12X-7M
100.537	300	7X-4M
102.133	3	16X-9M
103.410	15	9X-5M
105.325	30	11X-6M
106.693	10	13X-7M
107.719	50	15X-8M
108.525	7	17X-9M
109.155	30	19X-10M
110.112	30	23X-12M
110.796	25	27X-14M
111.309	20	31X-16M
111.708	20	35X-18M
114.900	2300	4X-2M
117.773	15	41X-20M
118.491	20	33X-16M
119.003	25	29X-14M
119.687	30	25X-12M
120.645	30	21X-10M
122.081	50	17X-8M
123.107	10	15X-7M
124.475	50	13X-6M
126.390	25	11X-5M
129.262	400	9X-4M
131.315	7	16X-7M
134.050	50	7X-3M
137.880	40	12X-5M
139.533	30	17X-7M

IV. MAINTENANCE.

A. WARRANTY.

For the warranty on this instrument, refer to the current BRC Catalogue.

B. GENERAL DISCUSSION.

Certain performance characteristics of the instrument are dependent on factory adjustment or checking with equipment *specifically designed* for the *purpose* and *unobtainable commercially,* hence indiscriminate attempts to obtain normal operation by adjusting other than panel controls are bound to result in deviations from specifications. In particular, adjustments of phase shift, crystal oscillator frequency, and attenuator calibration are not easily made using commercial test equipment.

The RF unit is factory-sealed to avoid possible tampering or adjustment by unauthorized personnel. It may, however, be opened* for tube testing or tube replacement, with the factory warranty being voided if our inspection shows damage or misalignment due to adjustments made by the customer.

As a general rule, the replacement of tubes in the 211-A generator does not require readjustment of circuit calibrations. However, since differences in interelectrode capacitances from tube to tube will cause some detuning of the RF tank circuits, it is preferable to replace the tubes in the RF unit only if they prove to be defective or inoperative, and to return all those judged to be satisfactory to their original socket positions.

Proper tracking of the master oscillator requires a technique acquired only by practice. Hence realignment in the field should be confined to adjustment of the trimmer capacitors C243 and C244 (Figure 9) of the first doubler and final doubler tank circuits to restore exact capacitive tracking at approximately 140 mc.

C. TROUBLE-SHOOTING.

Many cases of non-operation and of malfunctioning are the result of tube failure. A visual inspection will often show a tube inoperative, and its replacement will restore normal performance.**

If all tubes light, but performance is abnormal, the tubes should be checked in a tube tester, returning them, if good, to the sockets from which they were removed.

Replace any defective pilot lights to allow their use as a "power on" indicator and check fuses, F101 and F102 (Figure 7).

The output voltages of the two electronically regulated "B" supplies should be checked. The generator must be connected to the power supply for this test, and readings are best taken on the terminal board in the generator where the interconnecting cable terminates. Correct voltages to chassis are 200V (blue lead) and 575V (red lead) ±5%. If outside these ranges, reset, using P102 (200V) and P-101 (575V) in that order.

To facilitate the detection and localizing of possible trouble, two charts are presented on the following pages. The first, a "Trouble Chart", lists by symptoms some known trouble conditions and their remedies. The second, "Socket Voltage Chart", gives average operating potentials under the stated conditions.

TROUBLE CHART

SYMPTON	REMEDY
1. No meter readings. No control by meter ZERO ADJ controls.	B+ 200V inoperative. Fuse F104 (see Figure 7) located on the top of the power supply chassis may be open. Replace with 1/8A SLO-BLO type fuse.
2. PERCENT MODULATION meter capable of being set to zero with its ADJ ZERO control, RF MONITOR meter reading below zero and not capable of being zero'd by its ADJ ZERO control.	V204, the 12AX7 inside the RF unit, subnormal. Replace and recheck RF MONITOR meter zero.
3. More than 400V DC on the 200V supply output. Excessive ripple (hum).	V102, the 6X5GT low voltage rectifier, probably has a heater-cathode short. Replace, and recheck B+ 200V.
4. Operation and meter readings normal except that the RF MONITOR meter reading drops below "red line" when the PERCENT MODULTION meter reading is increased to 100%.	V203, the 6AK5 final-doubler is subnormal or has inadequate "drive". Replace with a normal 6AK5 and recheck at 100% modulation as described in paragraph III. B. Normal reduction of the RF MONITOR meter reading is less than 2% for 100% modulation. If reaction is still present, tune to 140 mc and set trimmer capacitors (see Figure 9) C243 (Buffer-Doubler) and C244 (Output-doubler) for maximum reading on the RF MONITOR Meter M302. (These trimmer capacitors are screw driver adjustments adjacent to the tube socket of the corresponding stage.) Then recheck at 100% modulation.

**To remove the shield can from the RF unit, remove the can clamp bracket. Set frequency dial at 88 mc. Holding one hand underneath the shield can, smartly rap the top of the can with the other hand. Once loosened, the can may be removed by pulling it straight away from its mounting plate and associated casting. When replacing the RF shield can, seat it by hand with moderate pressure, then install the clamp bracket and tighten only enough to hold the can as seated by hand.*

***V101, the 5R4GY high voltage rectifier, does not light for 40 seconds after power is applied, since its filament is connected through the 6N040 thermal delay relay K101. All other tubes in both power supply and generator should light immediately after turning the power switch on.*

SOCKET VOLTAGE CHART

Conditions:

Tune to 112 mc, switch to MO + XTAL, set the RF MONITOR meter to red line, and adjust for 30% of 400 cycle modulation.

Unless noted, all voltages are + DC measured to chassis with a 20,000 ohm per volt meter. To measure at starred points (*), solder a 100,000 ohm 1/2 watt carbon resistor in series with the negative probe. Keep resistor leads short.

AC voltages are to be measured with a 1,000 ohms per volt meter.

	Pin. No.	1	2	3	4	5	6	7	8	9
	Socket									
	K101		575	575		880		880		
	V101		880		660AC		660AC		880	
POWER SUPPLY	V102		200	410AC		410AC		200	350	
	V104	575	575	870	510	510		575		
	V105	195	200	200	200	510	320	200		
	V106	200	200	340		185		200		
	V107	70	75	75	75	185	220	75		
	V108					75				
	V207	*-6		6.1AC		115	115			
	V202	*-20		6.1AC		170	150			
RF UNIT	V203	*-25		6.1AC		200	75			
	V204	200		2.5			200	2.5	5	6.1AC
	V205	*-5		6.1AC		85	85			
	V206	*-45		6.1AC		125	125			
	V301		1.7		90		112		1	6.2AC
	V303	200		9	6.2AC	6.2AC	200	14.5	16	
GENERATOR	V304		6	2.3	200		135		2.5	6.2AC
	V305			320	200			6.2AC	8.5	
	V306	7.1AC		200		100		200		32

D. METER CALIBRATION AND ADJUSTMENT

The original factory calibration and adjustment of the meter circuits should not require attention unless the calibration potentiometer settings are disturbed. However, if desired, and if standardized meters of suitable accuracy are available, a re-calibration or check may be performed by following the detailed procedure outlined below:

Equipment:

DC Voltmeter

Range - 30 to 50V full scale (read 26V)
Resistance - 300,000 ohms or higher
Accuracy - 1% or better (as required for over-all error allowable)

AC Voltmeter

Ranges - approximately 10V and 25V RMS full scale (read 5.62V and 13.1V)
Impedance - 300,000 ohms or more at 400 cps. (must have series capacitor in input)
*Accuracy - 2% or better (as required for allowable error in results)

Procedure:

(See Figures 2 and 4 for identification)

FOLLOW SEQUENCE OF STEPS:

1. Parallel the AC and DC voltmeters, with the ground side of the AC voltmeter connected to the negative terminal of the DC voltmeter. Connect the paralleled combination between the arm of P304 and the negative terminal of the RF MONITOR meter M302. Make sure that the positive terminal of the DC voltmeter is connected to the arm of P304.
2. If the AC and DC voltmeters require mechanical "Zero" adjustment, it should be done before the 211-A is turned on.
3. After the 211-A has warmed up for several minutes turn the OSC SEL switch S303 to OFF. Electrically zero both the RF MONITOR meter M302 and the DC voltmeter, using the adjacent ADJ ZERO control P310.
4. Electrically zero the PERCENT MODULATION meter M301 using its adjacent ADJ ZERO control P309.
5. Switch the OSC SEL switch S303 to MO. Adjust the RF LEVEL control P307 to obtain exactly 26V DC as read on the DC voltmeter. The RF MONITOR meter M302 should read exactly on the red line. If it does not, reset it using P304.
6. Repeat steps 3, 4 and 5 for greater accuracy.
7. With the MOD switch S301 on the 400 position, adjust the MOD LEVEL control P305 for a reading of exactly 5.62V RMS on the AC voltmeter. Set the MOD RANGE switch S302 to 30%. If necessary, reset the RF MONITOR meter M302 to red line using the RF LEVEL control P307. The PERCENT MODULATION meter M301 should read 30%. If it does not, reset it, using P303.
8. Turn the MOD RANGE switch S302 to 100%. Readjust the MOD LEVEL control P305 for exactly 13.1 volts RMS as read on the AC voltmeter. Reset the RF MONITOR meter M302 to line (if necessary), using the RF LEVEL control P307. Read the PERCENT MODULATION meter M301. It should read 70%. If not, adjust with P302.

**It is essential that the accuracy of the voltmeters be established before their use as standards for this calibration.*

V. LIST OF REPLACEABLE PARTS

A. POWER SUPPLY

The following parts are replaceable. After replacement it is desirable to check the output voltage of the regulated 200V and 575V supplies. For this check the 211-A Generator should be connected to the power supply and the voltages set with P102 (200V) and P101 (575V) *in that order.*

Circuit Symbol	Description	BRC Part No.	Mfgr. & Mfgr's Designation
C101,2	Capacitor, fixed, paper, 4 μf +20 —10%, 1,000 W.V.	83076	CD-TCO 10040
C103,5,6	Capacitor, fixed, paper, 0.1 μf, 600 W. V.	83077	Fast. CP28A1EF104K
C104	Capacitor, fixed, paper, 10 μf, +20 —10%, 600 W.V.	83078	CD-TCO 6100
R101	Resistor, fixed, composition 82k 2W 5%	80569	AB-HB
R102,17	Resistor, fixed, composition 1M 1W 5%	80625	AB-GB
R103,4	Resistor, fixed, composition 470 ½W 5%	80170	AB-EB
R105	Resistor, fixed, composition 240k 1W 5%	80606	AB-GB
R106	Resistor, fixed, composition 27k 1W 5%	80487	AB-GB
R107	Resistor, fixed, composition 330k 1W 5%	80647	AB-GB
R108	Resistor, fixed, composition 270k 1W 5%	80666	AB-GB
R109,14	Resistor, fixed, composition 100k ½W 5%	80517	AB-EB
R110	Resistor, fixed, composition 680k ½W 5%	80663	AB-EB
R111	Resistor, fixed, composition 82k 1W 5%	80568	AB-GB
R112	Resistor, fixed, composition 22k ½W 5%	80472	AB-EB
R113	Resistor, fixed, composition 270k ½W 5%	80665	AB-EB
R115,16	Resistor, fixed, composition 24k 2W 5%	80456	AB-HB
P101,2	Potentiometer, composition 100k 2W	81507	
	Socket, octal ceramic	89047	Ucinite 115001/1A
	Socket, 7 pin miniature ceramic with shock shield	89027	Eby 102M
	Shield, tube (for 6AU6)	89088	Eby 7797
	Clamp, tube (for 6B4G and 5R4GY)	93629	Birtcher 926C
	Holder, fuse (for (3AG)	93667	Bussman HKP-H
F101,2	Fuse, 2A 3AG	93251	Littlefuse 312.002
F103,4	Fuse, ⅛A "S1oB1o" 3AG	93697	Littlefuse 313.125
T101	Transformer, Power	85078	
L101	Choke, filter, dual	85448	
K101	Relay, thermal delay, 6N040	91020	
V101	Tube, 5R4GY		
V102	Tube, 6X5GT		
V104,6	Tube, 6AS7G		
V105,7	Tube, 6AU6		

Circuit Symbol	Description	BRC Part No.	Mfgr. & Mfgr's Designation
V108	Tube, 0A3/VR75		
	Receptacle, box AN3102-22-24S	89070	Cannon 2063-56
—	Pilot light assembly	89022	Dialco BV-844S
I101	Pilot bulb No. 47, 6.3V at 0.15A	90904	Mazda No. 47
S101	Switch, toggle, ST22N	88059	A.H.&H. ST 22N

B. GENERATOR.

Replacement of any of the following components has negligible effect on performance or calibration accuracy:

Circuit Symbol	Description	BRC Part No.	Mfgr. & Mfgr's Designation
C301,2	Capacitor, fixed, mica .001 μf $\pm$5% 500 W.V.	82311	EM CM30A102J
C303	Capacitor, fixed, mica .01 μf $\pm$2% 300 W.V.	82414	EM CM40A103G
C304,9	Capacitor, fixed, paper 1μf 600 W.V.	83079	CD DYR 6100
C305,7	Capacitor, fixed, paper 4 μf $\pm$10% 600 W.V.	83034	CD TCOH 6040
C306	Capacitor, fixed, paper .1 μf $\pm$10% 600 W.V.	83077	Fast CP28A1EF104K
C308	Capacitor, fixed, mica .002 μf $\pm$5% 500 W.V.	82315	EM CM35A202J
C310	Capacitor, fixed, paper 2μf, 600 W.V.	83080	CD DYR 6200
C311	Capacitor, fixed, ceramic 47 $\mu\mu$f	82132	Erie (N330 $\pm$500 PPM JAN CC21SL470J)
C312	Capacitor, fixed, oil filled, 10μf, 600 W.V.	83078	CD-TCO 6100
C313	Capacitor, fixed, mica .01 μf $\pm$2% 300 W.V.	82414	EM CM40A103G
R301,3	Resistor, fixed, composition 390k ½W 5%	80664	AB-EB
R302,4	Resistor, fixed, composition 160k ½W 5%	80532	AB-EB
R305	Resistor, fixed, composition 1k ½W 5%	80148	AB-EB
R306	Resistor, fixed, composition 100k ½W 5%	80517	AB-EB
R307,319 326,329	Resistor, fixed, composition 470k ½W 5%	80640	AB-EB
R308,330 332,338	Resistor, fixed, composition 220 ½W 5%	80188	AB-EB
R309	Resistor, fixed, composition 15k 1W 5%	80337	AB-GB
R311	Resistor, fixed, composition 220k ½W 5%	80555	AB-EB
R312	Resistor, fixed composition 680k ½W 5%	80663	AB-EB
R313,14	Resistor, fixed, composition 47k ½W 5%	80304	AB-EB
R315	Resistor, fixed, composition 4.7k ½W 5%	80304	AB-EB
R317	Resistor, fixed, composition 1k ½W 5%	80148	
R318	Resistor, fixed, composition 150k 2W 5%	80529	AB-HB
R320	Resistor, fixed, composition 240k 1W 5%	80114	AB-GB
R322,35,36	Resistor, fixed, composition 2.5k 9W 5%	80290	Sprague Type 10KT

Circuit Symbol	Description	BRC Part No.	Mfgr. & Mfgr's Designation
R323	Resistor, fixed, wire wound 40k 9W 5%	80495	Sprague Type 10KT
R324	Resistor, fixed, composition 100 ½W 5%	80062	AB-EB
R327	Resistor, fixed, composition 6.8k ½W 5%	80387	AB-EB
R331	Resistor, fixed, composition 68k ½W 5%	80549	AB-EB
R333	Resistor, fixed, wire wound .64 2W 5%	80723	
R337	Resistor, fixed, composition 22k 2W 5%	80481	AB-HB
R339	Resistor, fixed, composition 2.7k ½W 5%	80225	AB-EB
R340	Resistor, fixed, composition 10k ½W 5%	80361	AB-EB
P305	Potentiometer, composition 100k 2W	81505	AB-J
P306	Potentiometer, composition 100k 2W ±10%	81507	AB-J
P307	Potentiometer, wire wound dual 40k 4W	81414	Clarostat 10 - dual 40-40k 4W ½" shaft linear taper
P309,10	Potentiometer, composition 500 2W	81117	AB-J
S301	Switch, rotary, ceramic wafer 3P3T	88086	
S302	Switch, rotary, ceramic wafer 1P2T	88087	
S303	Switch, rotary, ceramic wafer 4P2T	88088	
—	Index assembly 2P	88090	
V301,4	Tube, 2C51/396A		
V303	Tube, 12AX7		
V305	Tube, 6V6GT		
PL301	Connector, straight, AN-3106-22-24P	94125	Cannon 2081-55
I301	Bulb, pilot (no. 47) 6.3V at .15A	90904	Mazda No. 47
J301	Jack, phone	89096	Mallory A-1 "Infant"
J302	Jack, phone	89039	Mallory A-2A
—	Block, binding post	90041	
—	Post, binding	90042	Eby No. 11
—	Holder, pilot light	89022	Dialco BV-844S
—	Knob, pointer (Modified GR KNSP6)	87111	
—	Knob (Modified GR KN36)	87109	
—	Knob (Attenuator)	A300426	
—	Knob with crank (tuning)	A300429	
—	Knob (dial lock)	418052-9	
—	Socket, tube, 9 pin miniature bakelite	89086	Cinch 53F-12617
—	Socket, tube, octal ceramic	89047	Ucinite 115001/1A
—	Socket, 11 pin	89067	Amphenol MIP-11

The following components are replaceable, but after replacement the meters must be re-calibrated by following the procedure outlined under Par. IV. D., Meter Calibration and Adjustment.

Circuit Symbol	Description	BRC Part No.	Mfgr. & Mfgr's Designation
R310	Resistor, fixed, composition 47k ½W 5%	80460	AB-EB
R316	Resistor, fixed, composition 220k ½W 5%	80555	AB-EB
R328	Resistor, fixed, composition 100k ½W 5%	80517	AB-EB
P302	Potentiometer, composition 100k 2W	81507	
P303	Potentiometer, composition 25k 2W	81415	
P304	Potentiometer, composition 250k 2W	81601	
M301	Meter, Percent Modulation 100 μa	92039	
M302	Meter, RF Monitor 100 μa	92026	

Replacement of the following two components requires that the voltage output of the AF oscillator be reset to 12V RMS ($\pm$1V) as measured at the junction of P301 and C304 (Figure 5) using an AC voltmeter of at least 1,000 ohms per volt, and adjusting P301 until the proper reading is obtained.

Circuit Symbol	Description	BRC Part No.	Mfgr. & Mfgr's Designation
P301	Potentiometer, composition 2.5k 2W	81205	
V302	Lamp, 3W 115V	90907-1	GE 3S6/5

The following component requires adjustment, after replacement, to produce 170V DC on the MOD line (Pin 5 of the 11 pin socket X306) with the RF LEVEL control P307 full clockwise:

Circuit Symbol	Description	BRC Part No.	Mfgr. & Mfgr's Designation
P308	Potentiometer, composition 10k 2W	81336	

C. RF UNIT.

The following tubes may be replaced if necessary. See section IV. B., Maintenance, entitled, General Discussion.

Circuit Symbol	Description	BRC Part No.	Mfgr. & Mfgr's Designation
V201,2, 5,6,	6AK5 (Selected), BRC Type 543-B	91005-1	—
V203	6AK5 (Selected), BRC Type 543-A	91005-2	—
V204	12AX7		

VI. APPENDIX

THEORY OF EQUIVALENT CIRCUIT OF OUTPUT SYSTEM

The following general transmission line equation is found in W. L. Everitt's text "Communication Engineering" (1937 Edition, Equation 41, page 157).

$$(1)\quad Ir = \frac{Eg}{(Zr + Zs)\cosh\gamma l + \frac{(Zo + Zr\,Zs)}{Zo}\sinh\gamma l}$$

The symbols appearing above are defined as follows:

- Eg = generator voltage
- Er = receiving end voltage
- Zs = source impedance
- Zr = receiving end impedance
- Zo = characteristic impedance of transmission line
- Ir = line current
- l = length of the transmission line

We wish to find Er when $Zs = Zo$

Since the cable transmission is small $\gamma = j\beta$

$$(2)\quad \cosh\gamma l = \cosh j\beta\, 1 = \cos\beta 1$$

$$\sinh\gamma 1 = \sinh j\beta\, 1 = j\sin\beta 1$$

$$(3)\quad Er = Ir\,Zr = \frac{Zr\,Eg}{(Zr + Zo)\cos\beta 1 + j\,(Zo + Zr)\sin\beta 1}$$

$$(4)\quad \frac{Zr\,Eg}{(Zr + Zo)\,(\cos\beta 1 + j\sin\beta 1)}$$

The expression $(\cos\beta 1 + j\sin\beta 1)$ is a vector of unit amplitude which represents a shift in the phase of Er of $\beta 1$ radians with respect to Eg due to the length of cable. It is not relevent to this discussion and will be dropped.

$$(5)\quad Er = \frac{Zr}{Zr + Zo}\,Eg$$

From the above it can be seen that the transmission line under consideration obeys Ohms law for the special case when $Zs = Zo$.

Note that when $Zs = Zo$, the length of cable is immaterial providing its attenuation is small. Also no restriction is placed on Zr, so that the equivalent circuit is valid even though the receiving end is not properly terminated and standing waves exist on the line.

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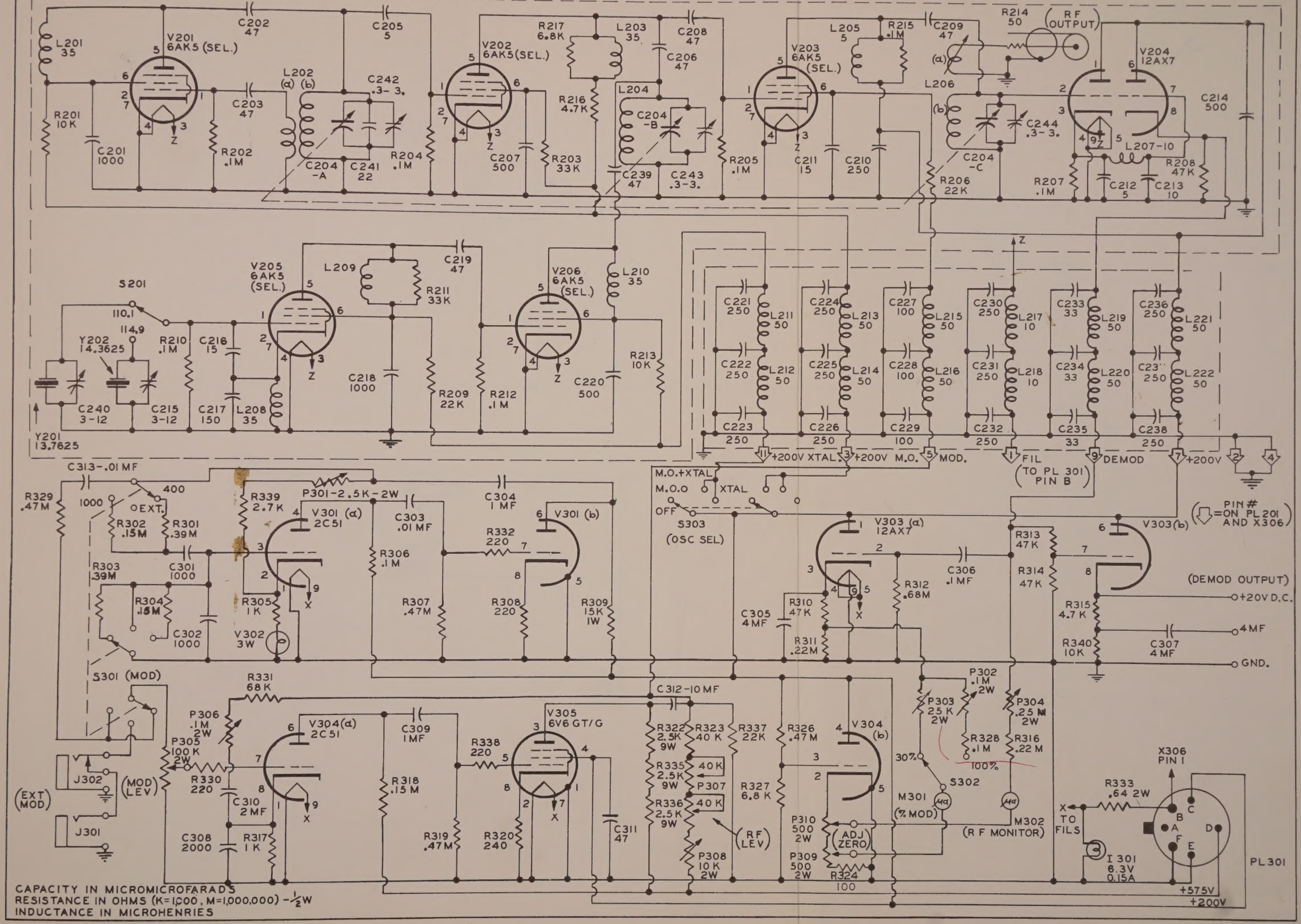

Fig. 9. Schematic Diagram of Type 211-A Signal Generator

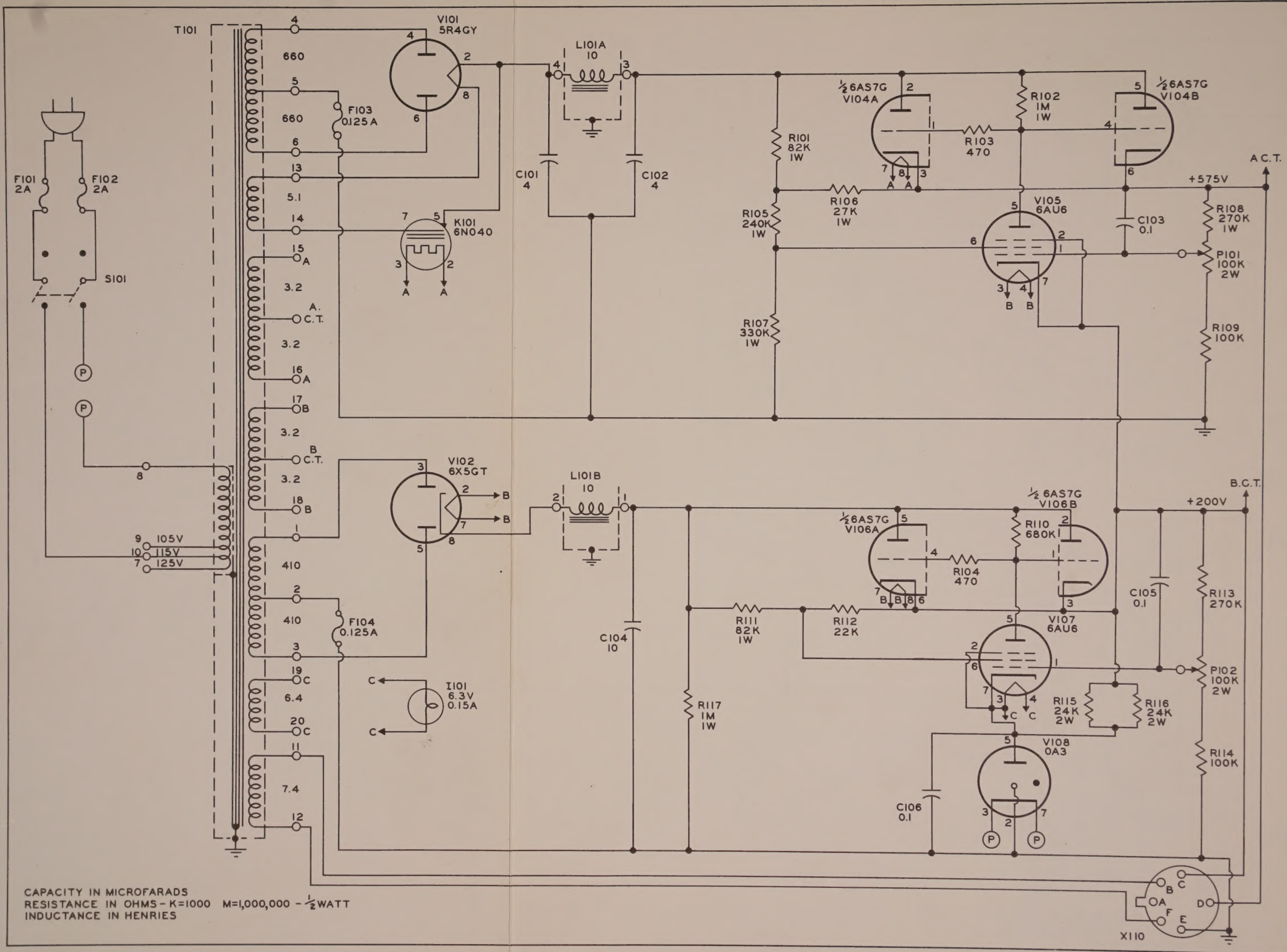

Fig. 10. Schematic Diagram of Type 211-AP1 Power Supply

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